Experiment Instruction Manual

General Instructions for Electricity and Magnetism Experiments

Compulsory education textbooks and experimental teaching aids

Table of contents

Optional experiments
(some models of experimental boxes do not include the following experiment contents)

Get to know experimental equipment

(This table is not a configuration list, some models of test boxes do not include all of the following equipment)


Ammeter


voltmeter


galvanometer


battery box

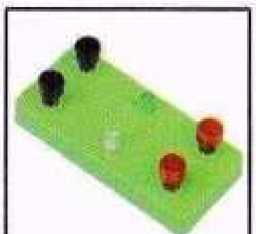

electric motor

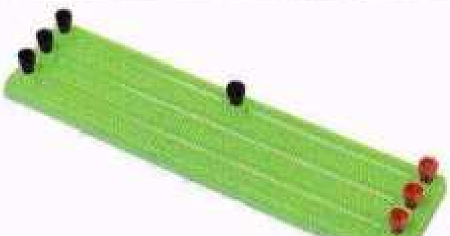

lamp holder


Single pole single throw switch


SPDT switch


Fixed value resistor


light emitting diode LED


Resistance law experimenter


hand generator


Unknown resistance


Magnetic switch

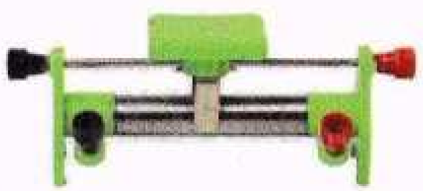

Ampere force tester


Magnetic levitation experimenter


small motor


solar power panel

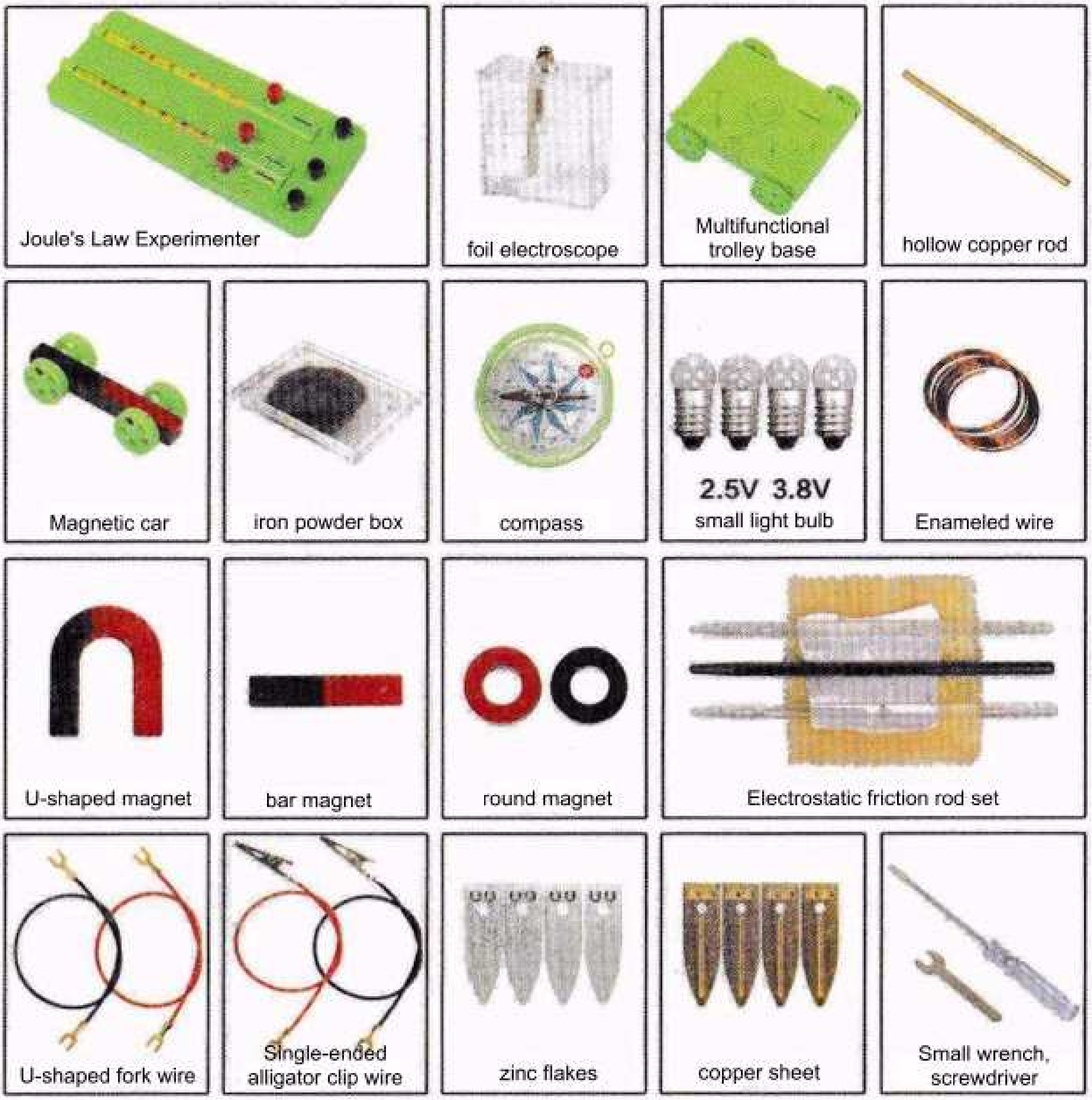

buzzer


20Ω Adjustable Rheostat


Multifunctional electric bell


electromagnet


square coil



Tips:

1. This product is equipped with three AAA dry batteries and cannot be powered by household AC power.

2. The electrical experiment processes involved in this set of experimental equipment are safe and controllable, so please feel free to use it.

3. This experimental manual is a general version. The pictures are for reference only. The model and configuration of the experimental box shall prevail.

1. How to compose a simple circuit

Learning objectives:

1. Understand the basic components of circuits and the functions of each component.
2. Master the three states of circuits: open circuit, open circuit, and short circuit.
3. Understand the hazards caused by short circuit and the application of local short circuit.

Equipment: battery box, batteries, switch, small lamp holder, wire

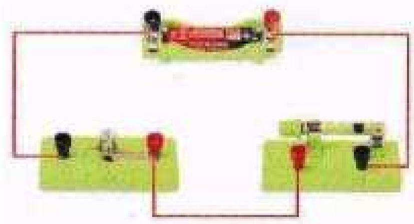


Figure 1-1

There are many electrical appliances in our home, and they all need to be connected into a circuit to work. So how can a circuit be formed? What are the elements that make up a circuit? Let's use small light bulbs as electrical appliances and make the simplest circuit by ourselves.

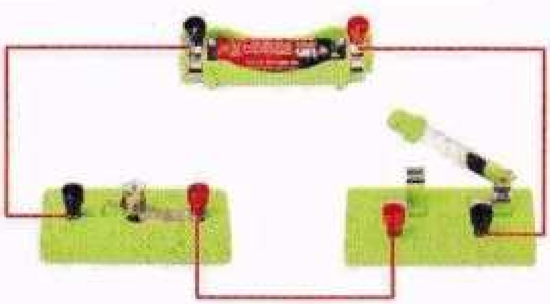


Figure 1-2: Circuit breaker

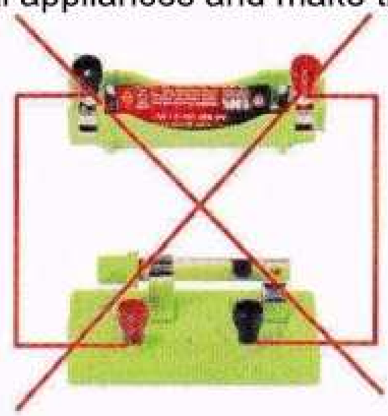


Figure 1-3: Incorrect connection method, the switch is closed and causes a short circuit

Experimental design:

1. As shown in Figure 1-1 and Figure 1-2, form a circuit and close the switch to make the circuit work. Understand what is a path?
What is a circuit breaker? Think about it: What are the components of the most basic circuit and what is the function of each component?
2. Why is the connection method shown in Figure 1-3 wrong? What will be the consequences? Think about and summarize the three states of the circuit.

Expand experimental research:

As shown in Figure 1-4, first close switch S2 and observe the light emission of the two bulbs, then close switch S1 and observe the light emission of the two bulbs again. Analyze the observed phenomena and analyze the current path under different switch states.

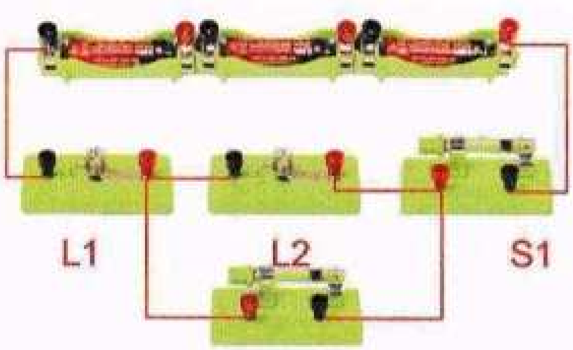


Figure 1-4: Close S1 and S2, bulb L2 short-circuited

Battery box usage tips:

Figure 1-4 shows the first time to connect three battery boxes in series. When the battery boxes are connected in series, the plastic card interface of the new equipment is relatively astringent, so the first connection may not be smooth. This is normal. Please patiently follow the operation instructions in Figure 1-5 and try several times. Generally, this problem will not occur after several uses. The three No. 5 battery boxes equipped with this equipment can be used independently, or two or three batteries can be connected in series or in parallel, which is free and flexible. The battery box connection instructions are shown in Figure 1-5, and the battery box parallel connection method is shown in Figure 1-6.

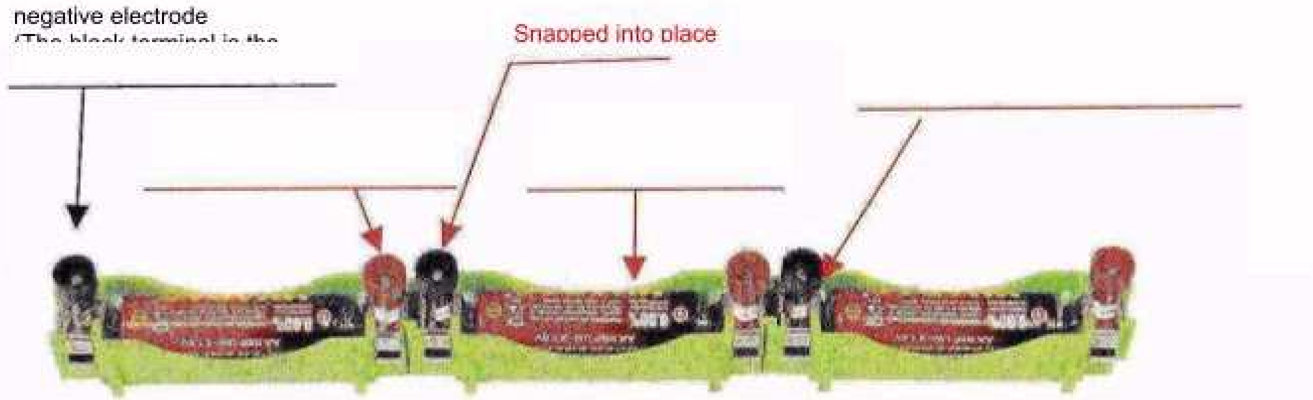


Figure 1-5: Battery series connection

Figure 1-6: Battery boxes connected in parallel to form a battery pack

2. Understanding series circuits and parallel circuits

Learning objectives:

1. Know what a series circuit is and be able to connect a series circuit.
2. Understand the basic characteristics of series circuits (the path of current and the impact of switch position on the circuit)
3. Know what a parallel circuit is and be able to connect basic parallel circuits
4. Understand the characteristics of parallel circuits, be able to distinguish between main circuits and branches, and know the functions of main circuit switches and branch circuit switches.

Equipment: battery box, batteries, switch, small light bulb, wires, small lamp holder.

Equipment: battery box, batteries, switch, small light bulb, wires, small lamp holder.

We connect a small light bulb to a circuit to form a basic simple circuit, but in real life, we have many electrical appliances connected to the same circuit, so how can we connect multiple electrical appliances to the same circuit? What are the connection methods? Let's use multiple small light bulbs to represent multiple electrical appliances connected to the circuit and see what connection methods are there.

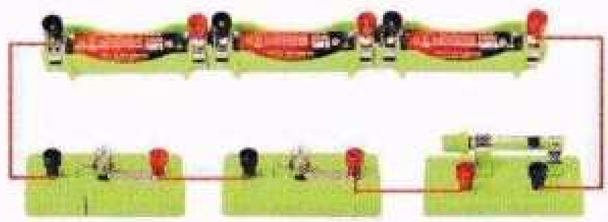


图2-1

Experimental design:

1. Assemble the circuit as shown in Figure 2-1, and observe and explore the characteristics of the circuit (outside the power supply, the current always flows from the positive pole of the power supply through the circuit to the negative pole).
2. Then change the connection method of the switch according to Figure 2-1 and Figure 2-3, study the switch function of the series circuit, and explore the characteristics of the series circuit.
3. As shown in Figure 2-4, form a parallel circuit and analyze the direction of current flow; close each switch separately to observe the function of each switch in the parallel circuit, and analyze and find out which part is the branch and which part is the main circuit.

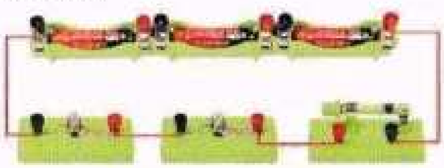


Figure 2-2

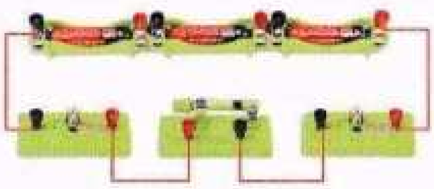


Figure 2-3

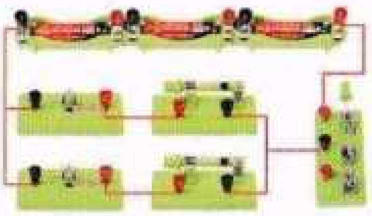


Figure 2-4

3. Measuring current with an ammeter

Learning objectives:

1. Understand the measurement range of the two ranges of the ammeter and the corresponding graduation values.
2. Be able to correctly connect the ammeter to the circuit and count using different ranges.
3. Be able to summarize the application methods and precautions of ammeter.
4. Develop the awareness and habit of selecting the measuring range by trial touch and estimation.

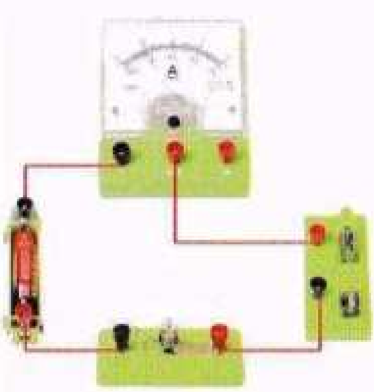


图3-1

Equipment: battery box, batteries, switch, ammeter, small light bulb, wires, small lamp holder.

Experimental design:

1. Connect the circuit as shown in Figure 3-1 to measure the current of a light bulb and learn the ammeter readings.
2. The connection method shown in Figure 3-2 is wrong. The ammeter is not allowed to be directly connected to the circuit in this way. Note: Before using the ammeter, check whether the pointer points to zero and adjust the knob to zero.

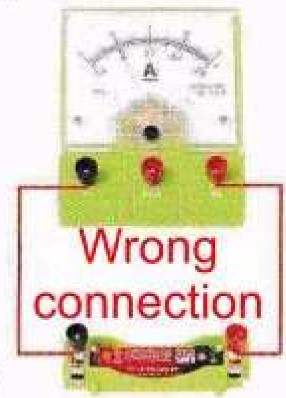


Figure 3-2

4. What are conductors and insulators?

Learning objectives:

1. Know what conductors and insulators are, and be able to distinguish which common objects are insulators and which are conductors.
2. Know that there is no strict boundary between conductors and insulators, and they can be converted into each other under certain conditions.
3. Understand what semiconductors are and their applications, and search the Internet for superconductivity.

Equipment: battery box, batteries, switch, ammeter, small light bulb, wires, small lamp holder.

In our daily life, all kinds of electrical appliances and switches are made of plastic, rubber and other materials on the outside, and copper, aluminum and other metals on the inside. The wires are also made of a layer of rubber on the outside and a copper core on the inside. Why is this?

Experimental design:

As shown in Figure 4-1, connect common school supplies such as erasers, knives, coins, and rulers (need to bring your own) to the circuit to see if the light bulb lights up, to determine whether these objects connected to the circuit can conduct electricity, and thus understand conductors and insulators.

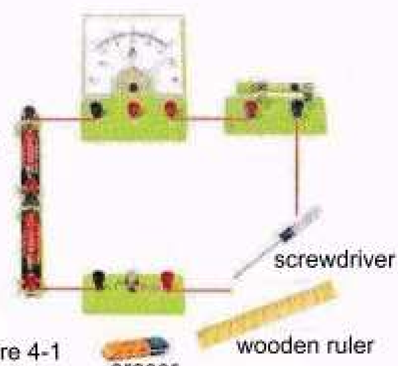


Figure 4-1

Knowledge expansion:

1. Normally, dry air is not easy to conduct electricity and is an insulator. However, under very high voltage, air can also break down and conduct electricity. For example, lightning between clouds is caused by the breakdown of air between clouds. This shows that there is no strict boundary between conductors and insulators. Generally, the division of conductors and insulators is based on common circumstances. Therefore, the definition of conductors and insulators is to distinguish whether they can or cannot conduct electricity.
2. Objects can be divided into conductors and insulators according to whether they are easy to conduct electricity. However, there is a class of objects whose conductivity is between conductors and insulators, called semiconductors. Semiconductors have unique applications due to their unique properties. You can refer to this information outside of class. (Diodes, integrated circuits, etc.)

5. Circuit diagram

Learning objectives:

To know the circuit diagram symbols of common electrical components and be able to draw circuit diagrams accurately and in a standardized manner.

2. Be able to draw the corresponding circuit diagram based on the actual object, and be able to connect the actual circuit according to the circuit diagram.

3. Have the initial ability to analyze circuits and be able to use the idea €13€13equivalent c to analyze circuits.

Equipment: battery box, batteries, switch, ammeter, small light bulb, wires, small lamp holder.

Building a high-rise building requires blueprints. There are all kinds of blueprints from daily life to scientific fields. Blueprints are the language of engineers all over the world. Similarly, designing circuits also requires circuit diagrams. Circuit diagrams are diagrams that use agreed-upon symbols to represent circuit connections. They are easier to communicate than physical diagrams and can reflect circuit connections more clearly and intuitively.

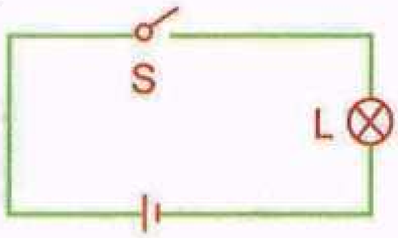
In the electricity part of junior high school physics, learning to identify circuit diagrams, design and draw circuit diagrams is a key to learning electricity. This process is also an important stage from perceptual knowledge to rational knowledge, and it is also the key to analyzing circuits. Through circuit diagrams, the various states of the circuit can be seen, and the connection methods and the relationships between various electrical physical quantities can all be reflected. It is no exaggeration to say that mastering circuit science to identify, analyze, and design circuits is the key to learning electricity, and it is a red line that runs through the electrical part, so we must develop the habit of drawing circuit diagrams to

Recognize the circu
symbols of various
components:

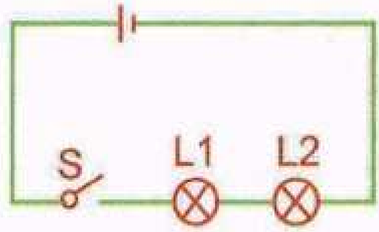
Each circuit component has a special symbol in the circuit diagram. For example, whether it is a storage battery, a No. 1 dry battery, or a No. 5 dry battery, the symbols in the circuit are the same because they have the same function.

Draw the circuit diagram according to the actual circuit connection:

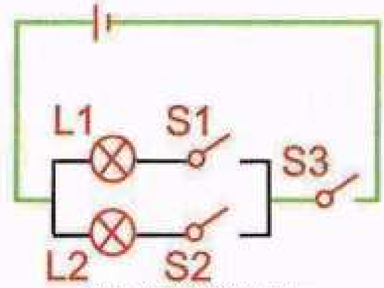
Previously, we used physical equipment to connect physical circuits by hand. Now we can also use circuit diagrams on paper based on the symbols above to represent the circuit. The circuit diagrams corresponding to the previous individual actual circuits are as follows:



The circuit diagram corresponding to Figure 1-3



The circuit diagram corresponding to Figure 2-1



The circuit diagram corresponding to Figure 2-4

From the above circuit diagram, we can see that the wires in the circuit are represented by straight lines, and they must be drawn horizontally and vertically to make the entire circuit diagram square. This is not only beautiful, but also clearer and more standardized, which facilitates communication. The wires in the circuit diagram do not indicate the actual length. In order to better understand how to draw circuit diagrams, you must practice more.

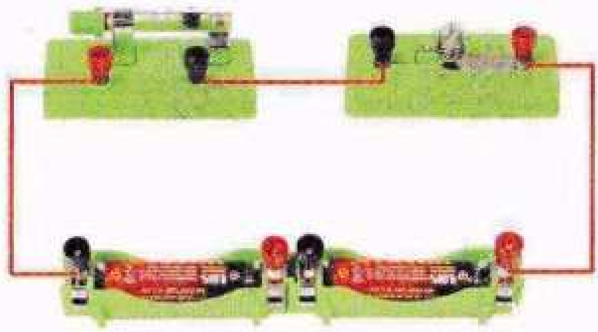


Figure 5-1

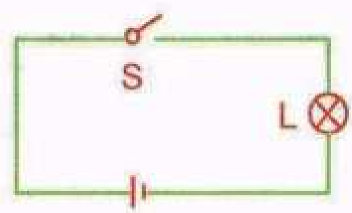


Figure 5-2

For relatively simple physical circuits, it is relatively easy to draw a circuit diagram for basic series and parallel circuits. As long as the circuit diagram can correctly reflect the connection method of the circuit and the order in which the current flows through each component, the circuit diagram can be accurately drawn. However, for some special physical circuits, the circuit must be simplified and analyzed, and the corresponding circuit diagram must be drawn after simplification based on the idea of €13€13equivalent ci Figure 5-1 and Figure 5-2 can be analyzed and simplified according to this process, and finally the circuit diagram can be drawn.

Knowledge tips:

1. The circuit diagram must be accurate and standardized: Accuracy means that each symbol in the circuit diagram must correspond to the actual circuit, and can reflect the connection method of the actual circuit, and the order of current flow must be the same; Standardization means that the proportions of components must be adapted. For example, if the circle representing the light bulb is larger than the other, or if the original component is placed at a corner, these are all non-standard.

2. The process of drawing a circuit diagram is not a simple drawing, but a process of analyzing the circuit. It is also a process of transitioning electrical knowledge from functional knowledge to rational knowledge.

6. Explore the current law of series circuit

Learning objectives:

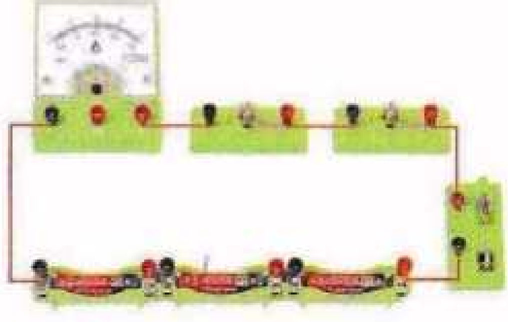


Figure 6-1

1. Understand the law of current size at various points in the series circuit.
2. Be able to use the current law of series circuits to perform circuit calculations.
3. We have learned how to connect series circuits. We have preliminarily explored some characteristics of series circuits.

Now we use an ammeter to further quantitatively explore the other characteristics of the series circuit.
Equipment: battery box, batteries, switch, ammeter, small light bulb, wires, small lamp holder.

Experimental design:

As shown in Figure 6-2 and Figure 6-3, connect the ammeter to several different places in the series circuit to explore the characteristics of the series circuit.

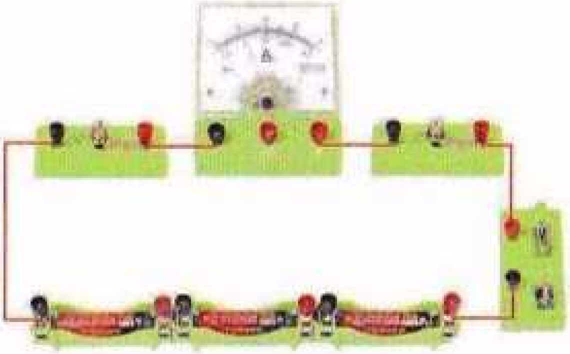


Figure 6-2

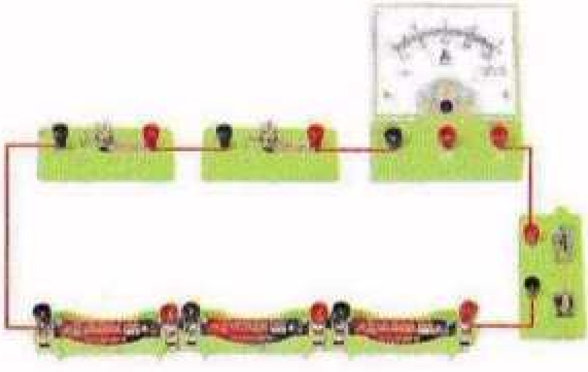


Figure 6-3

7. Study the current law of parallel circuits

Learning objectives:

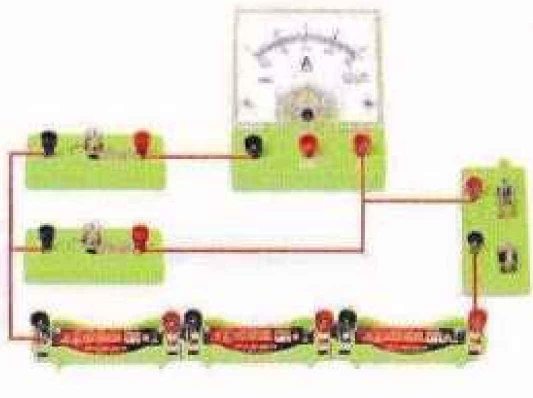


Figure 7-1

1. Understand the rules of parallel circuits and the current size of each branch.
2. Learn to use the laws of parallel circuit current for calculations.
3. Earlier we learned how to connect series circuits and preliminarily explored some of the characteristics of series circuits. Now we use the ammeter we have learned to further quantitatively explore the characteristics of series circuits.

Equipment: battery box, batteries, switch, ammeter, small light bulb, wires, small lamp holder.

Experimental design:

As shown in Figure 7-1, Figure 7-2, and Figure 7-3, connect the ammeter to the main circuit and each branch of the parallel circuit respectively, and explore the relationship between the main current of the parallel circuit and the current of each branch by analyzing the experimental data.

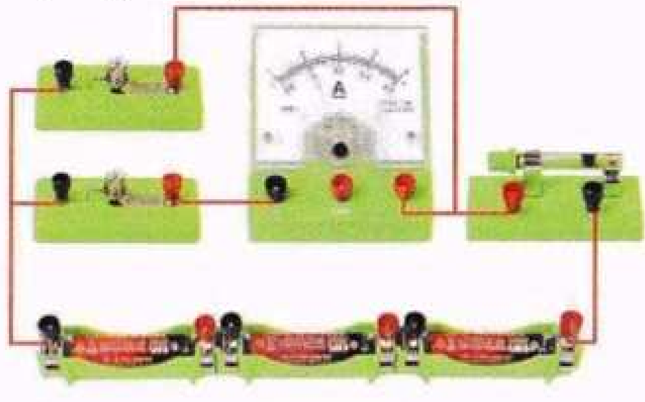


Figure 7-2

Figure 7-3

8. Measure voltage with a voltmeter

Learning objectives:

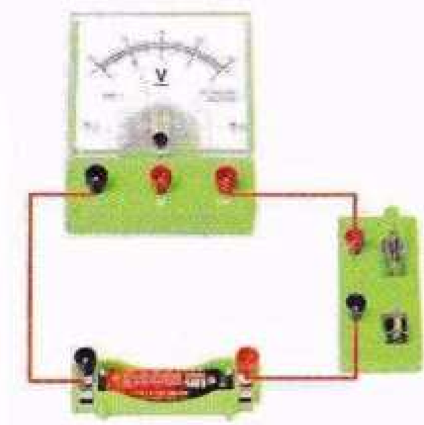


Figure 8-1

1. Understand the scale of the voltmeter, the two ranges of the voltmeter and the corresponding graduation values.
2. Be able to correctly connect the voltmeter to the circuit.
3. Further develop the habit of selecting the range by trial and error.
4. Summarize the usage and precautions of the voltmeter.
5. Know the relationship between the voltage of a series battery pack and each battery.

Equipment: battery box, batteries, switch, voltmeter, small light bulb, wires, small lamp holder.

Experimental design:

As shown in Figure 8-1, use a voltmeter to measure the voltage of one battery, the voltage of two batteries, and the voltage of three batteries.

Knowledge skill points:

1. Two or more batteries are connected end to end to form a series battery pack;
2. When using a voltmeter to measure voltage, you should consider the voltage size, select different ranges of the voltmeter, and perform a test touch;
3. The zero adjustment of the voltmeter pointer is the same as that of the ammeter.

9. Explore the voltage law of series circuits

Learning objectives:

1. Become more proficient in using a voltmeter to measure voltage.
2. Understand the relationship between the voltage of each part of the series circuit and the total voltage of the circuit.
3. Be able to apply the voltage law of series circuits to perform circuit calculations.

Earlier we studied the laws of current in a series circuit, so what are the laws of voltage in a series circuit?

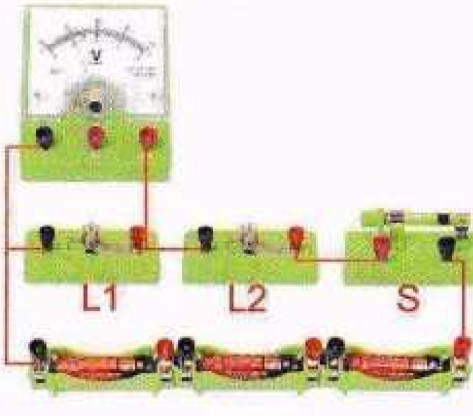


Figure 9-1

Equipment: battery box, batteries, switch, voltmeter, small light bulb, wires, small lamp holder.

Experimental design:

As shown in Figure 9-1, Figure 9-2, and Figure 9-3, the voltmeter measures the voltage across L1, the voltage across L2, and the total voltage of the entire circuit respectively. Analyze the experimental data and summarize the rules.

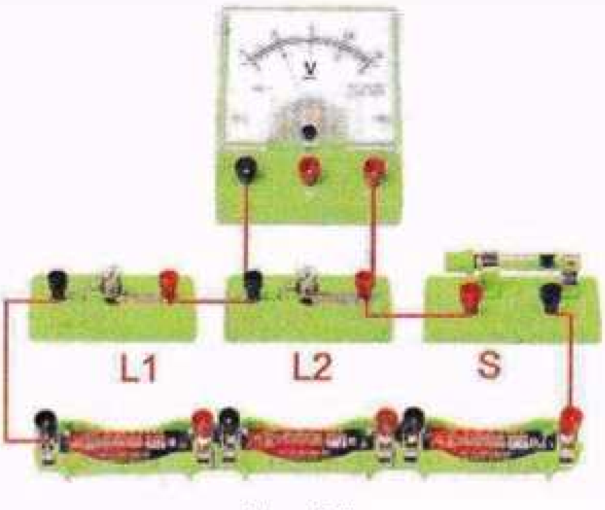


Figure 9-2

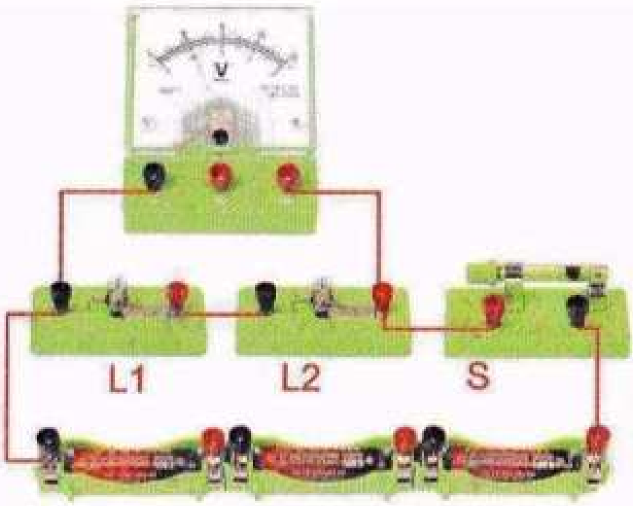


Figure 9-3

10. Explore the voltage law of parallel circuits

Learning objectives:

1. Understand the relationship between the voltage at both ends of each branch of a parallel circuit and the total circuit voltage.
2. Use the voltage of parallel circuits to calculate the current characteristics of parallel circuits. We already know that the main circuit current is equal to the sum of the branch currents, so what are the characteristics of the voltage of parallel circuits?

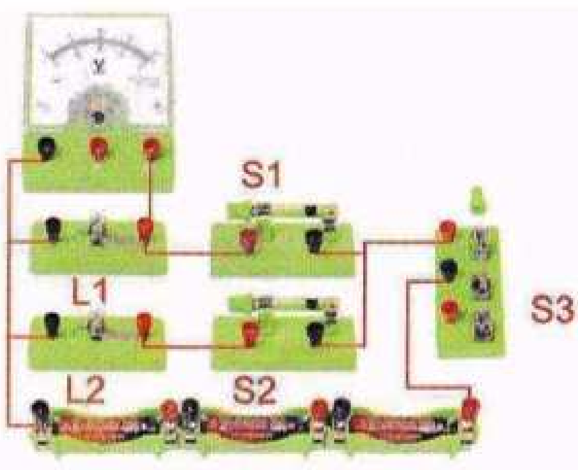


Figure 10-1

Experimental design:

Measure the voltage U1 across the bulb L1 as shown in Figure 10-1, and then measure the voltage U2 across L2 as shown in Figure 10-2. If the voltage U of the parallel circuit is measured as shown in Figure 10-3 and recorded separately, summarize the voltage law of the parallel circuit.

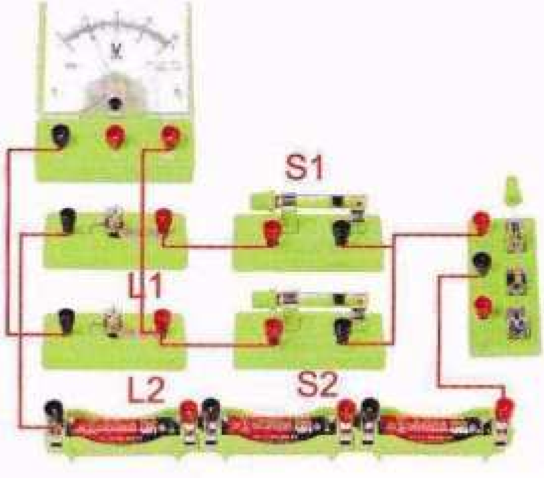


Figure 10-2

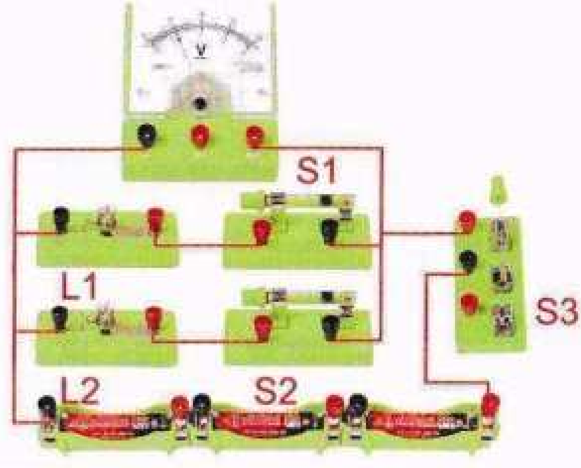


Figure 10-3

11. Explore the voltage law of battery packs in series

Learning objectives:

1. Understand the relationship between the voltage at both ends of each branch of a parallel circuit and the total circuit voltage.
2. Use the voltage of parallel circuits to calculate the current characteristics of parallel circuits. We already know that the main circuit current is equal to the sum of the branch currents, so what are the characteristics of the voltage of parallel circuits?

Figure 11-1

But what if the circuit usually requires different voltages? In fact, we have already solved this problem in the previous experiment.

Using several batteries in series can provide different voltages. Let's use an experiment to explore this problem.

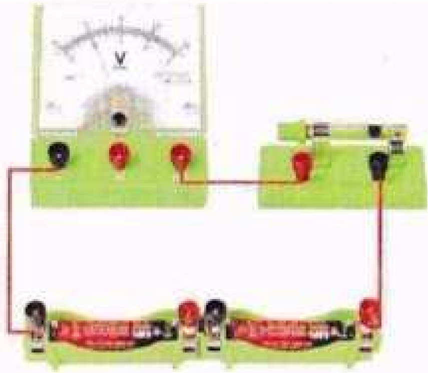


Figure 11-2

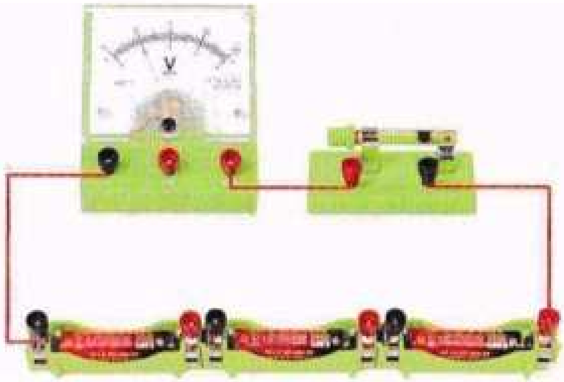


Figure 11-3

Experimental design:
As shown in Figure 11-1, use voltage to measure the voltages of the three batteries separately, then connect two of them in series and measure their voltages (as shown in Figure 11-2), and analyze the relationship between the total voltage of the two batteries in series and the voltage of each battery; then measure the relationship between the total voltage of the battery composed of three batteries and the voltage of each battery as shown in Figure 11-3.
Note: The battery boxes are connected in series. Pay attention to the methods and techniques when assembling and disassembling.

12. Explore the voltage law of parallel battery packs

Learning objectives:
1. Know what is battery parallel connection and the conditions for battery parallel connection.
2. Know the relationship between the total voltage of a parallel battery pack and each battery.
In the circuits we learn, it is common to connect batteries in series to form a battery pack to power the circuit. So can dry batteries be used in parallel? What are the characteristics of the voltage of parallel battery packs? In what occasions can it be used?
Experimental design:
Measure the voltage of a battery as shown in Figure 12-1, then connect batteries of the same voltage in parallel, as shown in the figure, and analyze the relationship between the voltage after parallel connection and the original voltage of each battery.

Figure 12-1 A battery pack consisting of two batteries connected in parallel

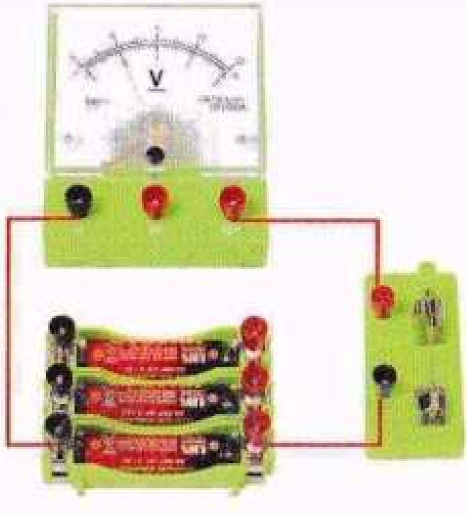


Figure 12-2 A battery pack consisting of three batteries connected in parallel

Knowledge expansion:
The same experiment shows that the total voltage of the parallel battery group formed by connecting the same voltage in parallel does not change; that is, parallel batteries cannot increase the voltage, but the same voltage batteries can reduce the internal resistance of the battery group and increase the output current after being connected in parallel; the power supply for electric vehicles is the battery group, which generally uses each 12V battery in series to increase the voltage, and then outputs a larger current through parallel connection, increasing the battery capacity; another example is the current solar power

The output voltage of each cell is low and the output current is very small. In actual use, multiple solar cells are often connected in series to increase the voltage and in parallel to increase the output current.

13. Measuring the operating current of light-emitting diodes

Learning objectives:

1. Understand the unidirectional conductivity of the diode
2. By measuring the energy-saving and environmental protection characteristics of light-emitting diodes
3. Understand the wide range of uses of light-emitting diodes and their development prospects as green light sources.

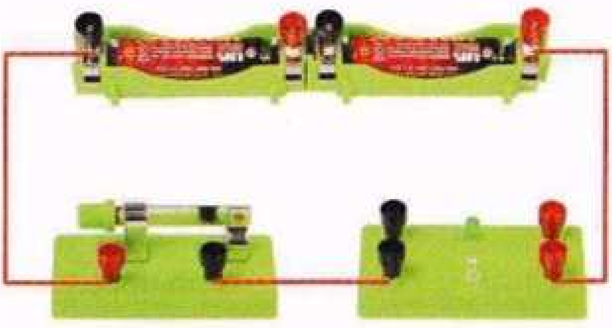


Figure 13-1 (Pay attention to distinguish the positive and negative poles when connecting)

Equipment: battery box, battery, switch, ammeter, wire, diode

Light-emitting diodes, or LEDs for short, are highly efficient light-emitting semiconductor devices that can convert electrical energy into visible light. They are made of materials such as gallium arsenide, gallium aluminum arsenide, and gallium phosphide. When making them, different materials are used, so they can emit light of different colors. The characteristics of light-emitting diodes are: very low operating voltage (some are only a little bit windy); very small operating current (some can emit light with only a few milliamperes); good impact and seismic resistance, high reliability, and long life. They are widely used in various instrument indicators and LED large screens; especially LEDs have broad prospects as efficient lighting sources.

Experimental design:

As shown in Figure 13-1, connect one of the light-emitting diodes to the circuit (note that the power supply uses two batteries in series, with a voltage of about 3V. If the voltage is too high, the diode will break down and burn out).

Change the current direction of the circuit, observe

Observe the light emission of the diode.

As shown in Figure 13-2, what is the current measured by the ammeter when the light-emitting diode is working normally?

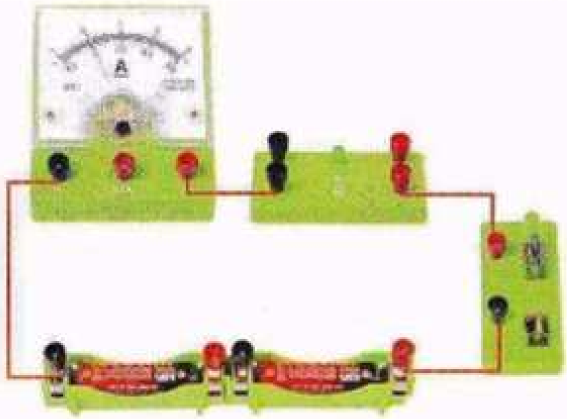


Figure 13-2

14. Explore the factors that affect the resistance of conductors

Learning objectives:

Figure 14-1

1. Know that resistance is a basic property of a conductor
2. Be able to state several factors that affect the resistance of a conductor. Equipment: battery box, battery, switch, ammeter, wire, and self-prepared pencil.

Resistance is the resistance of a conductor to current. Therefore, under the same voltage, conductors with different resistances have different currents passing through them. The greater the resistance, the smaller the current passing through.

We can compare the resistance of conductors by comparing the current passing through them at the same voltage; then what factors are related to the resistance of conductors? Let's explore this through experiments below.

Experimental design:

1. Use a pencil (self-prepared) to connect to the circuit as shown in the figure. Change the length of the pencil lead and observe the changes in the brightness of the ammeter and the bulb.
2. You can also use the above circuit to connect iron wires, copper wires, etc. of different lengths (materials prepared by yourself) between the alligator clips and observe the changes in circuit current.

15. Use a sliding rheostat to change the brightness of a bulb

Learning objectives:

1. Understand the structure of the sliding rheostat and know the principle of the sliding rheostat.
2. Be able to use the sliding rheostat correctly and know the characteristics of the six connection methods of the sliding rheostat.
3. Explore and understand the role of the sliding resistor in the circuit through experiments.

Equipment: battery box, batteries, switches, rheostats, wires

Through Figure 14-1 of the experiment in Topic 14, we can see that changing the length of the connected pencil lead can change the size of the connected resistance, thereby changing the current. In fact, there is a special similar experimental component called a sliding resistor, which can better achieve this function. As shown in the figure, let us understand the structure and use of the sliding resistor.

Experimental design:

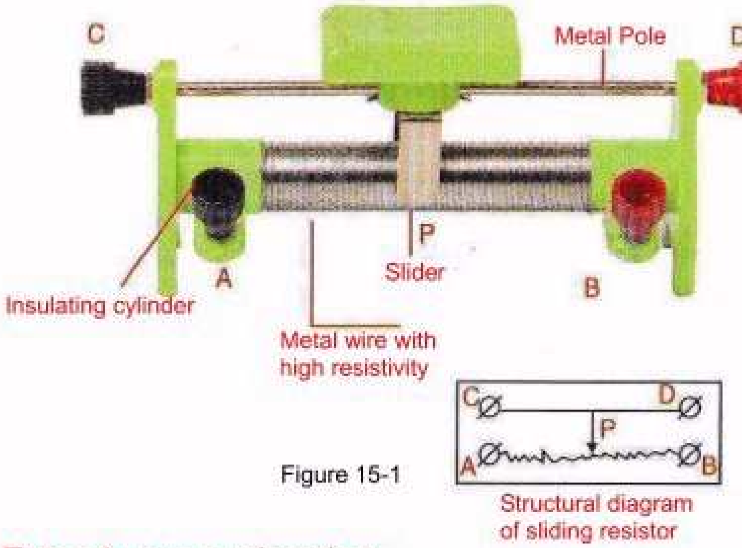


Figure 15-1

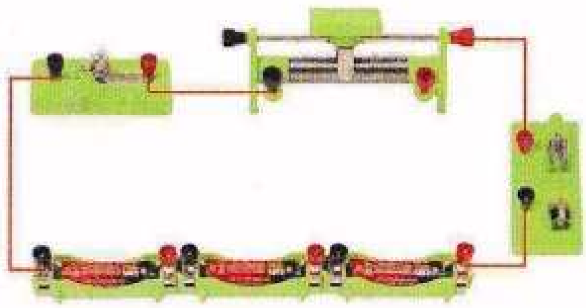


Figure 15-2

Extend your exploration:

The sliding rheostat has four terminals, and every two terminals are connected to the circuit in pairs, so there are six ways of connection. What are the differences between these six ways? Which methods can change the size of the resistance? In summary, what are the characteristics of the methods that can change the resistance value? How many methods cannot change the size of the resistance? What are their characteristics?

16. Ohm's Law

Learning objectives:

1. Understand the relationship between the current passing through a conductor and the voltage at both ends through exploration
2. Understand the relationship between the current passing through a conductor and the resistance of the conductor through an exploratory experiment
3. Summarize the relationship between current, voltage and resistance in a local circuit (a section of a circuit) to understand Ohm's law
4. Ability to use Ohm's law formula to perform circuit calculations (combining the current and voltage characteristics of the series circuit to perform calculations in the series circuit)

Equipment: sliding rheostat, ammeter, voltmeter, resistor, battery box, battery, switch, wire.

Current (1), voltage (U), and resistance (R) are the three most basic physical quantities in electricity. Through many previous experiments, we will think that the magnitude of the current passing through the circuit is related to the voltage. The higher the voltage, the greater the current may be. This is like water flow. The higher the water pressure, the greater the water flow. In addition, we know that the resistance of resistance to current is that if the current and voltage remain unchanged, if we connect a sliding rheostat in the circuit to increase the resistance, the circuit current will increase.

The smaller the current, the smaller the voltage, and the resistance. What is the relationship between the current, voltage, and resistance in a circuit? How can we express the relationship between the three?

guess:

1. Conjecture about the relationship between current and voltage: the higher the voltage applied to the same circuit, the greater the current.
2. Conjecture about the relationship between current and resistance: When the voltage remains unchanged, the circuit resistance increases and the current may decrease.

Experimental design:

Through the previous experimental phenomena, we can guess that the current may be affected by both the voltage and the resistance. So when we design experiments to quantitatively study the relationship between current, voltage and resistance, we should study them separately. Next, we use a fixed resistor to replace a conductor or a circuit to explore the relationship between these three physical quantities.

1. As shown in Figure 16-1, we study the current passing through the fixed resistor R (let R = 10 ohms remain unchanged), change the voltage across the fixed resistor by changing the sliding rheostat (it is best to measure the voltage change several times to an integer multiple), and at the same time measure and record the current passing through the fixed resistor to analyze the relationship between current and voltage.

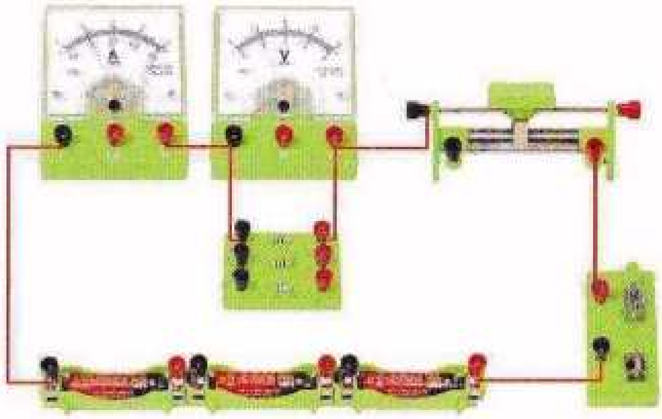


Figure 16-1

Table 1: Resistance = 10 ohms

Number of Experiments	Voltage (V)	Current (I)
Experiment 1		
Experiment 2		
Experiment 3		

2. Also use the circuit shown in Figure 16-1, connect 5 ohm and 15 ohm resistors respectively, adjust the sliding rheostat each time to keep the voltage across R unchanged, measure and record the change in current in the circuit at the same time, and summarize the relationship between current and resistance.

Method instructions:

In the above experiment, since the current through the conductor is affected by both the voltage and the resistance, when we study the relationship between current and voltage, we should keep the voltage at both ends of the circuit constant.

The resistance remains unchanged; when studying the relationship between current and resistance, the voltage should be kept unchanged. This method is called the controlled variable method.

The so-called controlled variable method is that when a problem is affected by multiple factors (variables), when we study the relationship between them, we often artificially keep other quantities unchanged and change one of the factors (variables) to explore the law of the influence of this factor on the problem. The controlled variable method is the most common and effective scientific research method for exploring physical laws in junior high school physics experiments.

17. Use a voltmeter and an ammeter to measure resistance

Learning objectives:

1. Use a voltmeter and an ammeter to measure the current of a conductor.
Resistors (can draw diagrams and connect circuits).
2. Reduce errors by taking average values €13€13t multiple measurements and deepen understanding of the concept of resistance.
3. Understand that resistance is a property of a conductor and has nothing to do with whether the conductor is conducting electricity or not.
4. Understand the principle of measuring resistance using the volt-ampere method

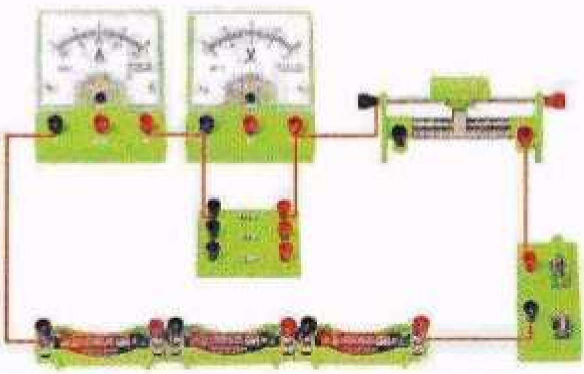


Figure 17-1

Equipment: fixed value resistor, voltmeter, ammeter, battery box, battery, switch, sliding rheostat, wire.

Measurement is the basis of the experiment. Through previous learning, we know that the current can be quantitatively measured with an ammeter, and the voltage can be measured with a voltmeter. Then the resistance of a conductor is also a physical quantity, and it also has different sizes. Since we do not introduce instruments to directly measure resistance in junior high school, do we have other ways to measure the physical quantity of resistance? In fact, after learning Ohm's law, there is a way to indirectly measure the resistance of a conductor.

Experimental design:

As shown in Figure 17-1, use one of the fixed value resistors as the unknown resistor RX, measure the voltage across it and the current through it, and record them in the table. In order to reduce the error, the voltage across the measured resistor and the current through it can be changed by adjusting the sliding rheostat to perform multiple measurements. The measurement data is recorded in the following table:

Frequency	Voltage U/V	Current I/V	Resistor to be measured RX (Ω)	Resistor RX average
1				
2				
3				

18. Use a voltmeter and an ammeter to measure the power of a small light bulb

Learning objectives:

1. Know the principle of measuring the power of a small light bulb, be able to connect circuits, and be able to draw circuit diagrams.
2. Understand the relationship between the brightness of a small bulb and its actual power through exploration.
3. Further understand the difference between the rated power and actual power of a bulb.
4. Use the volt-ampere method to measure resistance, measure the resistance of the small bulb under different working voltages, and analyze the reasons.

Equipment: sliding rheostat, ammeter, voltmeter, small light bulb, battery box, batteries, switch, wire, small lamp holder.

Power (P) is a physical quantity that indicates how much electrical energy an electrical appliance consumes in a certain period of time. Therefore, measuring the power of an electrical appliance is very helpful for us to understand the rated power and actual power. Next, we will use the indirect method of measuring resistance using the volt-ampere method to measure the power of a small light bulb.

Experimental design:

Observe the numbers on the small bulb and identify the normal working voltage of the small bulb (that is, the rated voltage. The rated voltage of the small bulbs we often use in experiments is generally 2.5V and 3.8V). As shown in Figure 18-1, adjust the sliding rheostat. First, let the voltage across the bulb reach its working voltage, and at the same time measure the working current passing through the small bulb (Note: the current passing through the bulb under the normal working voltage is also called the rated current); and observe the brightness of the bulb; then adjust the bulb voltage to be higher than its rated voltage (it should not exceed 1.2 times its normal working voltage, otherwise it will easily burn out), measure and record the bulb current and observe the luminescence, and then change the bulb voltage to be lower than its rated voltage, measure the current and observe the brightness of the

To be measured / working electricity	Voltage across the light bulb (V)	Current flowing through the light bulb (A)	Power of small bulb (W)	Light bulb lighting condition	Small light bulb filament resistance (ohm)
lower than rated voltage					
equal to rated voltage					
higher than rated voltage					

Extend your exploration:

Using the experiment and measurement data in the figure above, combined with Topic 17, we can calculate the filament resistance of the small light bulb. Analyze the data. What patterns will you find? When we studied the resistance experiment before, we knew that resistance is a property of conductors and has nothing to do with voltage and current. So is this the case with the filament resistance in this experiment? Analyze the reasons.

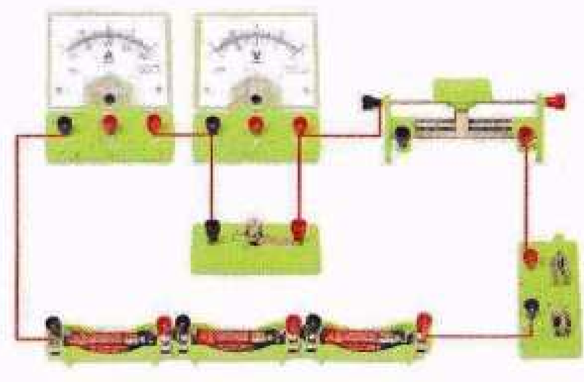


Figure 18-1

19. Understand simple magnetic phenomena

Learning objectives:

1. Understand the magnetic poles of a magnet and know what magnetism is.
2. Through experimental research, summarize the interaction laws between magnetic poles.
3. Know what magnetization is and its applications, and know what magnetic materials are and their applications.

The compass is one of the four great inventions of ancient China. The compass utilizes a property of magnet. Ancient China had a relatively early understanding of magnetic phenomena and made great achievements. Many students have played with magnets. Now let us explore the magnetic phenomenon in depth.

Experimental design:

As shown in Figure 20-1 and Figure 20-2, place a bar magnet or a tellurium-shaped magnet on the configured iron powder box and observe which part of the magnet attracts the most iron filings. Through exploration, think about the magnetic properties of different parts of the magnet. Which part does the magnetic pole of the magnet refer to?

Hang a bar magnet with a thin wire, allowing it to swing freely in the horizontal plane, and then observe where the two ends of the magnet point to when it is still.

Take a magnet and bring the two ends marked with N and S close to each other, feel the magnetic force between them, and summarize the interaction rules between magnets.

20. Magnetic Field and Magnetic Induction Lines

Learning objectives:

1. Understand the existence of magnetic fields and know that magnetic fields have directions.
2. Know what magnetic flux lines are and be able to draw magnetic lines around common magnets.

The induction lines are used to describe the magnetic field.
Equipment: U-shaped magnet, iron powder box
In the previous exploratory experiments, we know that the magnet does not need to touch the iron nail, but it can have a strong effect on the nail as long as it is close to it. The attraction and repulsion of the magnetic poles of the magnet can also have a strong effect without contact. What is the reason for this? It turns out that there is a special invisible and intangible substance around the magnet called the magnetic field. Let us now explore some properties of the magnetic field.

Experimental design:

1. Place a small magnetic needle next to the magnet, and then constantly change the position of the small magnetic needle around the magnet, observe the changes in the direction of the small magnetic needle, and think about what this phenomenon indicates.
2. According to Figure 20-1 and Figure 20-2, place the bar magnet and the U-shaped magnet on the iron powder box respectively. Hold the magnet with your hand, first gently shake the iron powder box horizontally, then tap the iron powder box with your fingers, and finally observe the distribution of iron filings in the iron powder box. Analyze and think about the distribution of magnetic fields around bar magnets and U-shaped magnets.

Figure 20-1 U-shaped magnet

Knowledge tips:

1. By observing the changes in the direction of the small magnetic needle in different places around the magnet, it is shown that the small magnetic needle is affected by the magnetic field of the magnet, which shows that the magnetic field has a direction, and the direction of the magnetic field in different places around the magnet is generally different.
2. By observing the iron filings in the iron powder box, you can better understand the magnetic field. After the iron filings are magnetized by the magnetic field of the magnet, each tiny iron filing can be considered as a tiny magnetic needle. The directio of the iron filings can show the different directions of the magnetic field. The places with more iron filings indicate that th magnetic field is strong.
3. Through experimental research, we found that the magnetic field has a direction. In order to better describe the magnetic field, scientists were inspired by the image of iron filings being magnetized and proposed the method of magnetic lines of forc which is to draw some imaginary curves in the magnetic field.

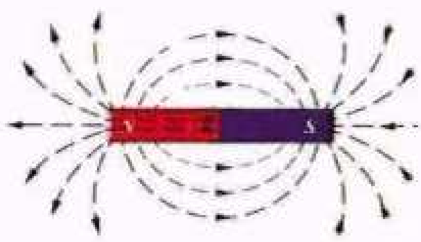


Figure 20-2 Bar magnet

Figure 20-3

The tangent direction of a point indicates the direction of the magnetic field at that point. The magnetic flux lines are drawn densely where the magnetic field is strong, and the sparse magnetic flux lines indicate a weak magnetic field. Based on the characteristics of the magnetic field, it can be concluded that the magnetic flux lines start from the N pole of the magnet and return to the S pole. Figure 20-2 shows the magnetic field of a bar magnet described by magnetic flux lines.

4. The magnetic lines of force should be understood in this way: they are an artificial method of describing the magnetic field. They do not really exist. They are just a means to describe the direction and strength of the magnetic field, and to visualize the invisible and intangible magnetic field. According to the characteristics of the magnetic field, the magnetic lines of force cannot cross. The magnetic lines of force are closed curves, which start from the N pole outside the magnet and return to the S pole. The magnetic lines of force inside the magnet should point from the S pole to the N pole.

21. Oersted Experiment

Learning objectives:

1. Know the Oersted experiment and its significance.
2. Know the factors that affect the direction of current and magnetic field.

Equipment: battery box, batteries, compass, switch.
Humans have known about magnetic and electrical phenomena for a long time, but before the 19th century, scientists believed that electrical and magnetic phenomena were

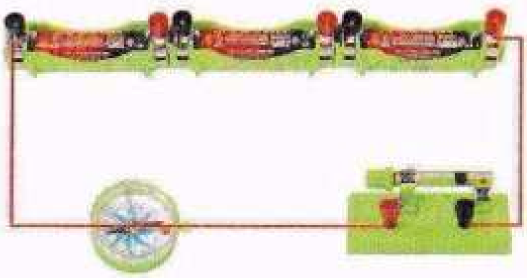


Figure 21-1

In the past, they were isolated and studied separately. However, in the 1820s, Danish scientist Oersted discovered the connection between electrical and magnetic phenomena for the first time. From then on, he opened up one scientific discovery after another of electromagnetic phenomena for mankind and laid the foundation for mankind to enter the era of electricity. Let us now learn about Oersted's experiment.

Experimental design:

As shown in Figure 21-1, place the wire above the small magnetic needle along the N and S poles of the small magnetic needle, then quickly close and open the switch, observe the reaction of the small magnetic needle at the moment of power-on, then change the direction of the current passing through the wire, and observe the reaction of the small magnetic needle again.

22. Solenoid and Ampere's Law

Learning objectives:

1. Understand the magnetic field distribution of an energized solenoid.
2. Know the relationship between the magnetic poles of a current-carrying solenoid and the direction of the current. The Oersted experiment was originally to study the magnetic field of the current around a straight conductor. After the success of the Oersted experiment, Ampere bent the current-carrying conductor into a ring, and later wound it into a multi-turn spiral coil to explore its magnetic field distribution. Now let us explore the magnetic field of Ampere's current-carrying solenoid.

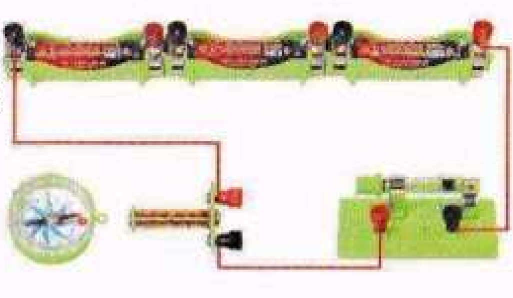


Figure 21-1

Equipment: solenoid (electromagnet), battery box, batteries, compass, wire, switch.
Experimental design:
As shown in Figure 22-1, place a small magnetic needle close to different parts of the energized solenoid to determine the magnetic field conditions of the solenoid, find out the N and S poles of the energized solenoid, then change the direction of the current passing through the solenoid and observe whether the magnetic poles of the solenoid change.

Knowledge tips:
Through a lot of experimental research, it is known that the magnetic field distribution of the energized solenoid is similar to that of a bar magnet.

The magnetic pole is related to the direction of the current. The direction of the current and the magnetic pole of the solenoid can be determined as shown in the figure. Hold the solenoid with your right hand, and the direction of the four fingers is consistent with the direction of the current. The thumb points to the N pole of the solenoid. This method is called Ampere's law.

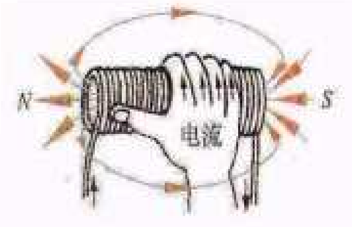


Figure 22-2

23. Electromagnet

Learning objectives:

1. Know the structure and principle of electromagnet.

2. Know which factors are related to the magnetic strength of electromagnets.

3. Understand the application of electromagnets in various occasions. When the solenoid is energized, it will generate a magnetic field, which is similar to a bar magnet, but the magnetism is limited. So how to increase the magnetism of the solenoid? Let's explore it below.

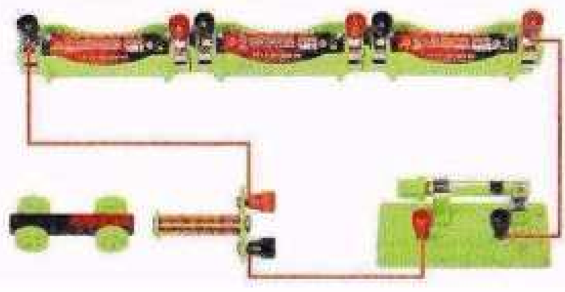


Figure 23-1

Equipment: ammeter, solenoid (electromagnet), battery box, battery, sliding rheostat, compass, wire, switch close.

Experimental design:
As shown in Figure 23-2 and Figure 23-3, the magnetic changes are compared by adjusting the sliding rheostat.

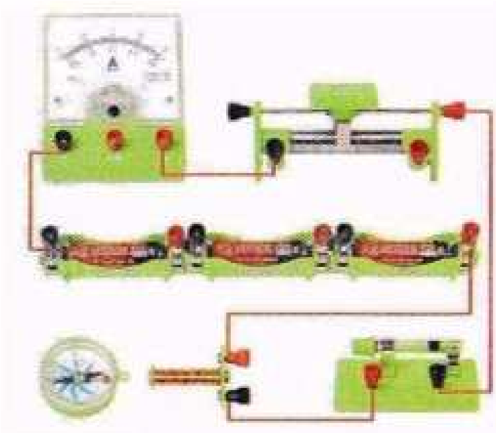


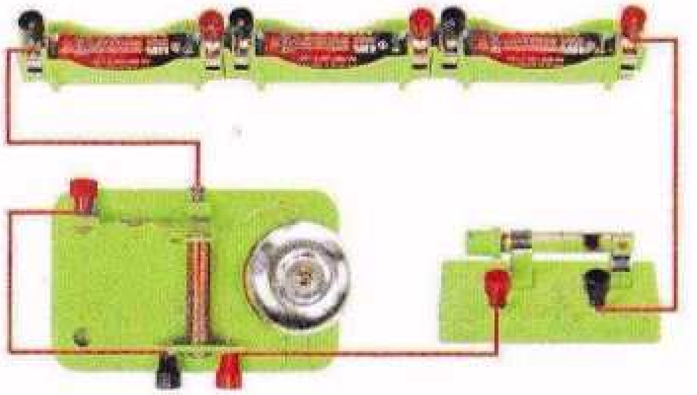
Figure 23-2

24. Understand the principle and usage of electric bell

Learning objectives:

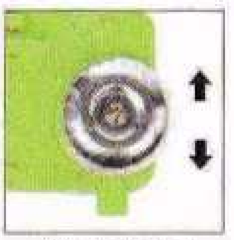
1. Understand the components and functions of the doorbell;
2. Be able to use electric bells to form basic control circuits;
3. Understand the application of doorbells.

[Principle]: Magnetic effect of electric current: When electricity is turned on, the electromagnet has current flowing through it, generating magnetism, which attracts the elasticity under the hammer, causing the hammer to hit the bell and make a sound. At the same time, the circuit is disconnected, the electromagnet loses its magnetism, the hammer is bounced back, and the circuit is closed. This process repeats continuously, and the bell makes a continuous hitting sound, as shown in Figure 24-1.

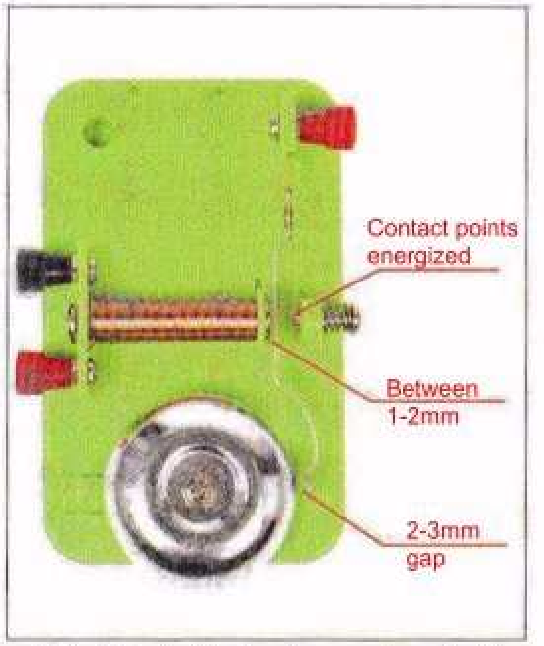


Wiring method

Contact point adjustment screw



Adjustable bell position



【Electric bell adjustment comparison chart】

25. Effect of Magnetic Field on Current-Carrying Conductors

Learning objectives:

1. Know that magnetic field has a strong effect on current-carrying conductors;
2. Know which factors are related to the direction of force acting on a conductor carrying current.

Equipment: Ampere force tester, battery box, U-shaped magnet, hollow copper rod, switch.

Using the principle of electromagnetic induction, humans invented generators to provide us with a large amount of electrical energy, which is then converted into other energy for our use through electrical appliances, such as heat energy through electric heaters and light energy through electric lights. So how do we get a lot of kinetic energy (mechanical energy) from electrical energy in our daily and industrial lives?

Of course, this requires an electric motor. So why can an electric motor convert electrical energy into mechanical energy? Let's explore how electrical energy is converted into kinetic energy.

Experimental design:

As shown in Figure 25-1, we learn the names of the various parts by comparing them with the research equipment. When assembling the equipment, we need to adjust the two copper rails to be on the same horizontal plane, put the small copper needle-shaped conductor between the upper and lower magnets, connect the power supply according to the diagram to form a circuit, and quickly try touching the switch when starting the experiment (that is, disconnect it immediately after closing it). This will generate a huge instantaneous current through the rails and the copper needle-shaped conductor, and observe the phenomenon that occurs.

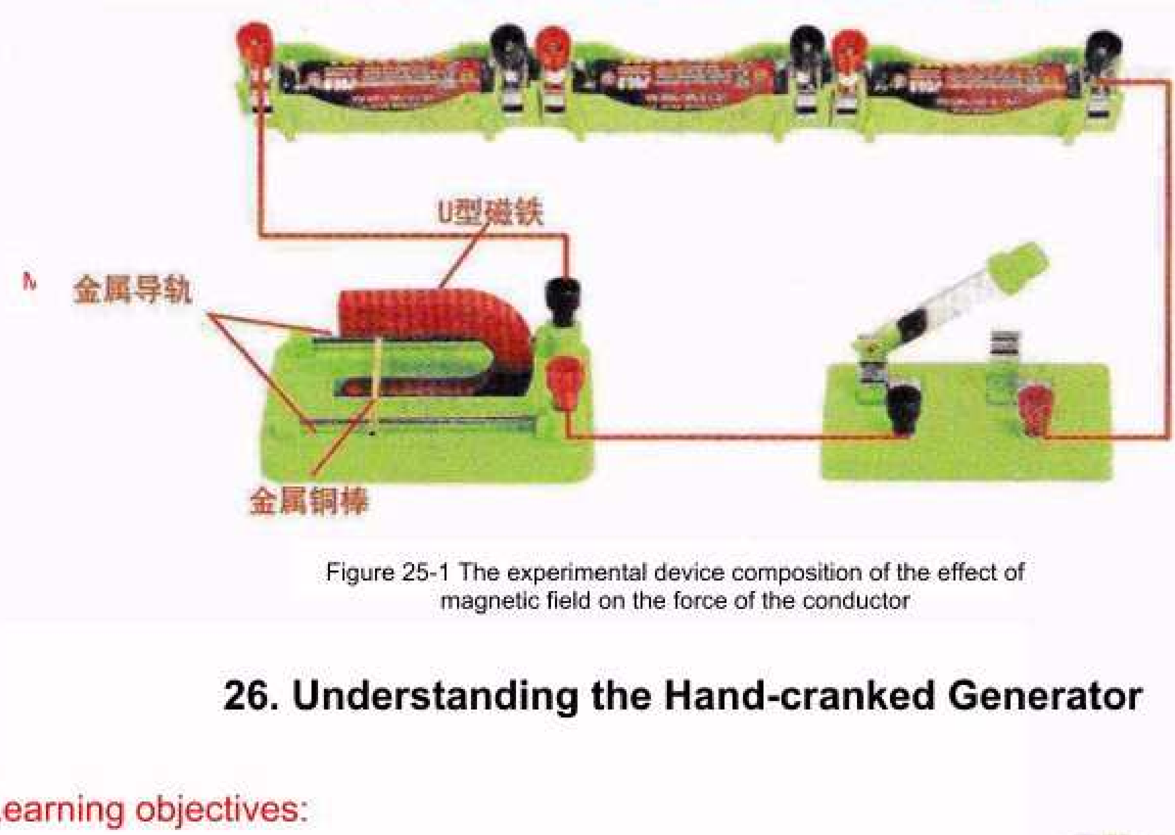


Figure 25-1 The experimental device composition of the effect of magnetic field on the force of the conductor

26. Understanding the Hand-cranked Generator

Learning objectives:

1. Understand the basic structure of DC hand-cranked generator;
2. Know the basic principles of generators.

Equipment: lamp holder, bulb, wire, hand-crank generator, ammeter, voltmeter.

Experimental design:

1. As shown in Figure 26-1, shake the hand-cranked generator and observe whether it emits light.
2. As shown in Figure 26-2, observe whether the pointer of the ammeter rotates? And study whether the rotation direction affects the direction of the current?

Figure 26-1

3. As shown in Figure 26-3, observe whether the pointer of the voltmeter will rotate? And study how many V it can reach?

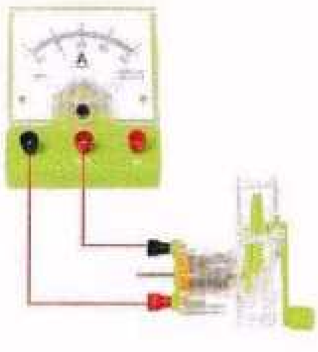


Figure 26-2

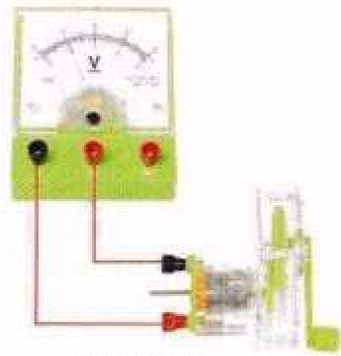


Figure 26-3

27. Experimental Device for Exploring the Law of Resistance

Resistance Law Experimenter:

1. Application: Resistance law sliding rheostat, battery, battery box, switch, ammeter, voltmeter, wire.
The following experiments can be done:
    1. Definition of conductor resistance
    2. Verify the resistance law
    3. Determination of conductor resistivity
    4. Study the series and parallel connection of conductors
2. Structure: This instrument consists of two nickel-chromium wires and one copper wire, which are installed on a plastic base plate.
3. Usage: as shown in Figure 27-1
4. Maintenance and repair:
    1. Pay attention to protect the metal wire to prevent it from breaking.
    2. Keep the terminals clean and in good contact.
    3. The power supply voltage should not be too high during use, and the power-on time should not be too long to avoid value changes.
    4. It should be placed in a dry and cool place at different times to avoid moisture and deterioration.

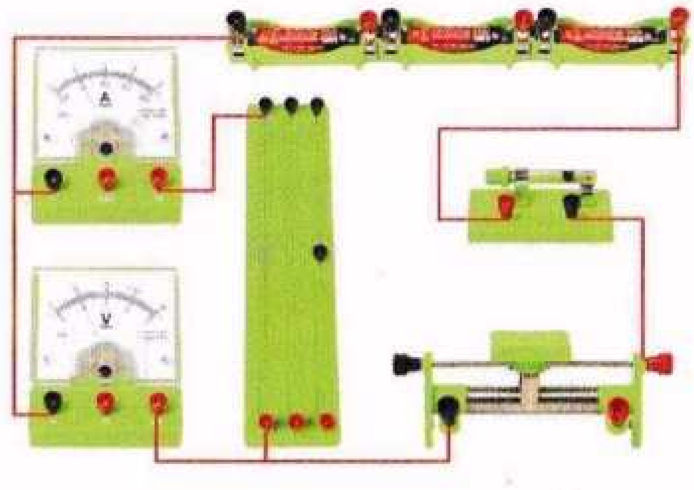


Figure 27-1

28. Understand DC motors

Learning objectives:

1. Understand the structure and names of various parts of DC motors;
2. Know the working principle of the motor and the energy conversion process;
3. Explore the factors that affect the rotation direction and speed of the motor.

Equipment: electric motor, ammeter, battery box, battery, switch, wire.

Fans, washing machines, air conditioners, many such electrical appliances in our lives are powered by motors, from the small motors on the four-wheel drive cars that students play with, to the razors used by men, to the electric locomotives on high-speed railways, various industrial vehicles, and agricultural pumps. All of these are inseparable from various motors. Motors are an important tool for humans to convert electrical energy into kinetic energy. Let's learn about its structure and working principle from the small motors in our hands!

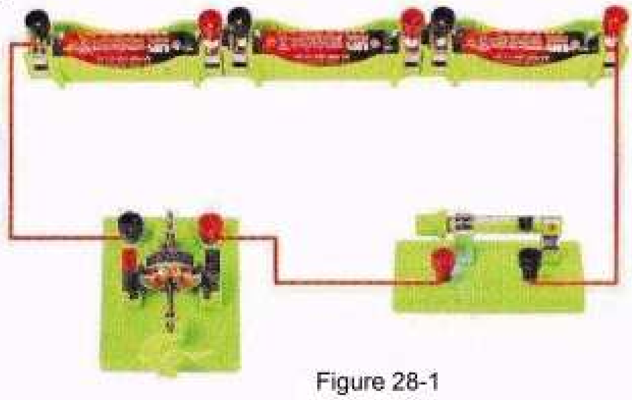


Figure 28-1

29. Fruit generates electricity

Learning objectives:

Explore the principles of primary batteries
Equipment: Voltmeter, fruit battery metal sheet
Two electrodes made of different metals are inserted into fruits and vegetables. One electrode is positively charged and the other is negatively charged. Under the action of the voltage between the two electrodes, the electrons in the wire move in a directional manner, thus forming an electric current.

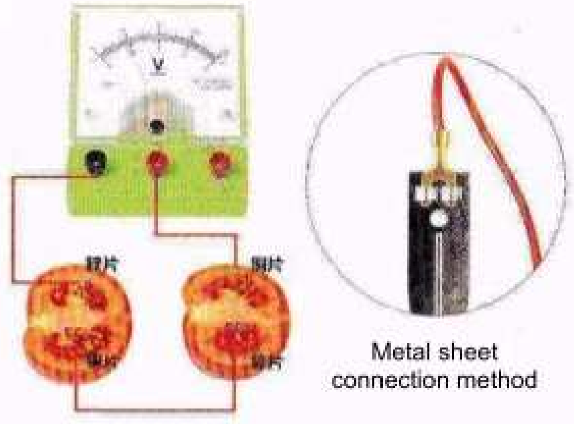


Figure 29-1

Experimental design:

Connect the circuit as shown in Figure 29-1. Insert the metal sheet into fruits or vegetables (you can choose fruits or vegetables with more water) and observe the changes in the pointer of the voltmeter.

(Some models of experimental boxes do not include the following experimental contents)

(Optional experiment) 30. Static electricity experiment

learning objectives:

1. Understanding the electroscope
2. Use an electrometer to test whether an object is charged

Equipment: Black rubber stick, imitation fur, electroscope
(Or you can use plexiglass rods and silk)

Figure 30-1

Experimental design:

1. Hold a rubber stick and rub it vigorously with the brush several times.
2. Use the part that has been rubbed by the rubber stick to touch the metal part at the top of the electroscope and observe what happens to the metal foil?
3. Note: When the air humidity is high, the experimental effect will not be obvious.

(Optional experiment) 31. Faraday's electromagnetic induction experiment (magnetoelectricity)

Learning objectives:

Explore the conditions and laws that produce electromagnetic induction
Experimental principle: When Faraday first studied the phenomenon of electromagnetic induction, he used a very strong magnetic field or a very strong constant current to conduct experiments to see if current would be generated in adjacent circuits. After many failures, he finally discovered that "magnetic induction of electricity" is a phenomenon that can only occur in the process of movement and change.
Equipment: sensitive galvanometer, square coil, bar magnet

Experimental design:

Connect the circuit as shown in Figure 31-1. Move one end of the magnet back and forth quickly in the square coil. Observe the change of the pointer in the sensitive galvanometer. The sensitive galvanometer is used to check the weak current or small voltage generated in the circuit. Generally, it is impossible to measure the specific value, so there is no need to adjust to zero.

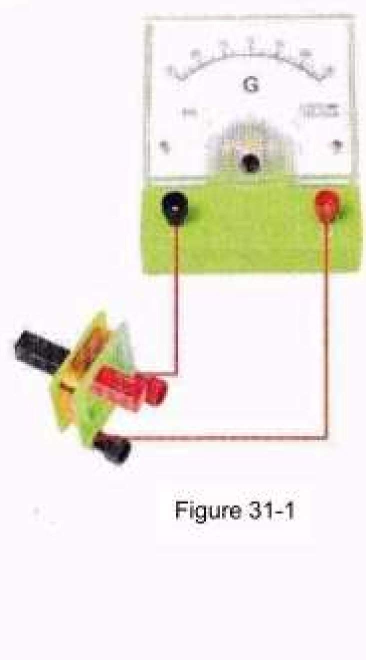


Figure 31-1

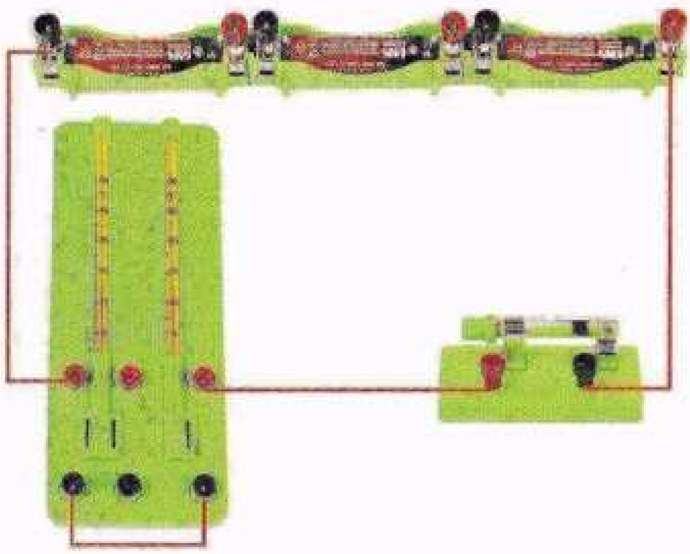
Note: The current intensity passing through the ammeter should not exceed the full-scale current value at any time. Do not mistake the ammeter for an ammeter or voltmeter and connect it to the circuit.

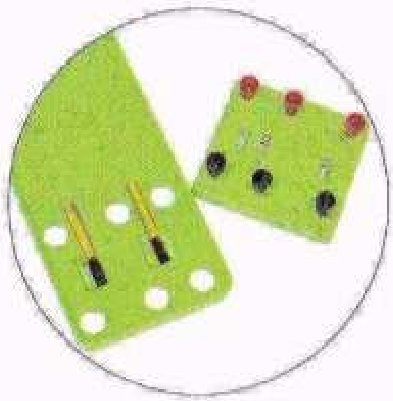
(Optional Experiment) 32. Explore the Thermal Effects of Electric Current

In daily life, many electrical appliances generate heat when they are connected to the power supply. When the current passes through the conductor, the electrical energy is converted into internal energy. This phenomenon is called the thermal effect of the current. The amount of heat generated is proportional to the square of the current, proportional to the resistance of the conductor, and proportional to the time of power on.
Equipment: Joule's law experiment device, battery box set, switch

Experimental design:

Assemble the equipment as shown in Figure 32-1, close the switch, and observe the readings of the two thermometers after a period of time.
What does the phenomenon you see indicate?





Split structure

Figure 32-1

(Optional experiment) 33. Magnetic levitation experiment

Equipment: magnetic levitation base plate, vertical pole, ejector pin, baffle, round magnet, rubber ring.

Experimental design:

1. Vertical magnetic levitation: Insert the vertical pole into the base, and put the round magnets into the vertical poles in pairs, and the magnets will levitate independently.
2. Horizontal magnetic levitation: First place the four magnets with their poles in the same direction and install them on the magnetic levitation base. As shown in the figure, install the two magnets, ejector pins, and rubber rings on the vertical pole in the same direction. Insert the baffle into the base. Adjust the position of the rubber ring and magnet until they are balanced.

Figure 33-1

(Optional experiment) 34. Magnetic switch experiment

Learning objectives:

Exploring the characteristics of magnetic switches
Equipment: Magnetic switch, bar magnet, LED, battery pack, switch

experimental design:

Connect the circuit as shown in Figure 34-1. Close the switch and observe whether the LED is powered on and emits light. Bring one end of a bar magnet close to the glass tube in the magnetic switch from above and observe whether the LED emits light.

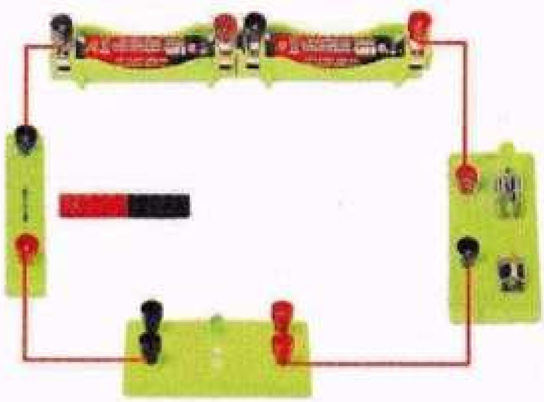


Figure 34-1

(Optional Experiment) 35. Solar Cell Power Generation

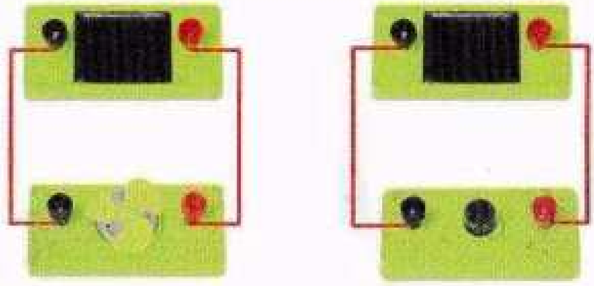
Learning objectives:

Learn about solar energy and its conversion
Because solar energy is widely distributed, easy to obtain, and does not cause environmental pollution, it is one of the ideal energy sources for mankind in the future.

Equipment: Solar panels, small motors or buzzers

Experimental design:

Connect the circuit as shown in Figure 35-1. Place the solar panel under sunlight. Observe the small motor or buzzer.



35-1

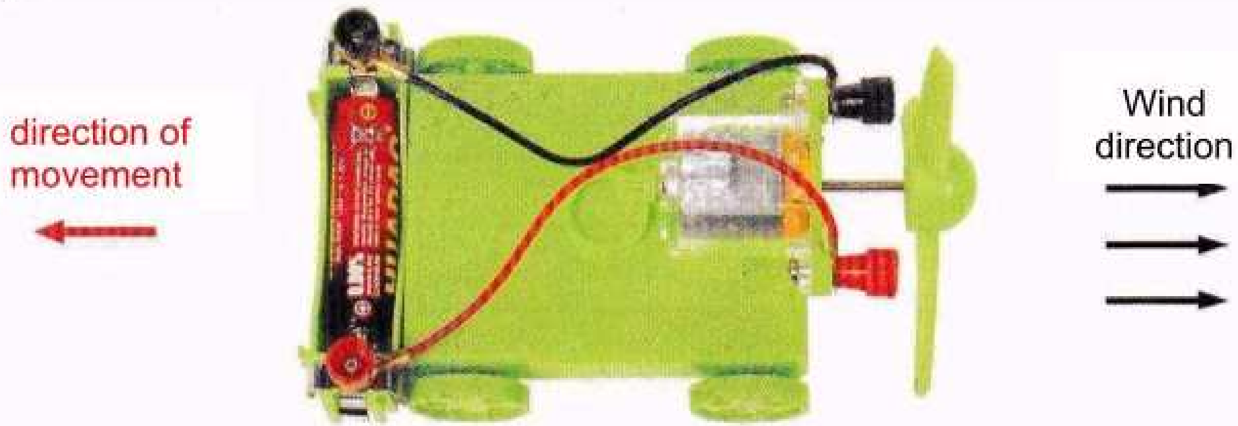
(Optional experiment) 36. assembly wind power car

learning objectives:

Explore energy conversion experiments
Equipment: Multifunctional trolley base, small motor, battery box, wire, fan blade

Experimental design:

Assemble the wind car as shown in Figure 36-1. Install the battery, and the small motor drives the blades to rotate to generate wind energy. The car moves under the power of the wind. Observe whether the rotation direction of the blades is related to the movement direction of the car.



Replacing the positive and negative poles of the battery can change the direction of rotation of the small motor

Figure 36-1

warranty card

Unit/school			
Contact address			
Contact number			
Purchase date			
Survey items	Satisfaction (choice)		
Initial use of the product	☐ Very satisfied	☐ satisfied	☐ Not satisfied
Exquisite appearance design	☐ Very satisfied	☐ satisfied	☐ Not satisfied
salesperson service	☐ Very satisfied	☐ satisfied	☐ Not satisfied
Any thoughts or comments?			

Change record	Change date	Cause of failure	Seal (signature)

Junior high school mechanics experiment set

Junior high school optics experiment kit

Junior high school electricity and magnetism experiment set

Magnetic electrical demonstration box